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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of: 2800

Murray FIGOV et al.

Serial No: ~~09/117,406~~ 09/525579

Filed: July 24, 1998

For: **AN IMAGING APPARATUS FOR EXPOSING A PRINTING MEMBER AND PRINTING MEMBERS THEREFOR**

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CLAIM FOR PRIORITY

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Sir:

Applicant hereby claims priority under 35 U.S.C. Section 119 based on Israel application No. 116885 dated 24 January 1996.

A certified copy of the priority document is submitted herewith.

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Respectfully submitted,

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116885	מספר Number
24-01-1996	תאריך: Date
	הוקדם/נדחה Ante/Post-dated

חוק הפטנטים,התשכ"ז - 1967
PATENTS LAW, 5727-1967
Application for Patent - בקשה לפטנט

אני (שם המבקש, מענו ולגבי גוף מאוגד - מקום התאגדותו)
(Name and address of applicant, and in case of body corporate-place of incorporation)

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Hebrew - עברית: מערכת לחשיפת מדיום להדפסה

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בקשת חלוקה Application of Division	בקשת פטנט מוסף Application for Patent Addition	דרישה דין קדימה Priority Claim		
מבקש הפטנט From Application No ____ מס' dated ____ תאריך	To Patent/Appl. לבקשה/לפטנט No ____ מס' dated ____ מיום	מספר\סימן Number\Mark	Date - תאריך	מדינת האגוד Convention Country

יפוי-כח:כללי\מיוחד-רצוף בזה\עוד יוגש
POA:general\~~individual~~-attached\~~to be filed later~~

filed in case 111014 הוגש בענין

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רח' משכית 22
א.ת. הרצליה, 46733

Signature of Applicant — חתימת המבקש

עבור המבקש,
משרד עורכי דין, טלי א. איתן - זאב פרל ושות'

P-IO-844-IL

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AN IMAGING APPARATUS FOR EXPOSING A PRINTING MEMBER

מערכת לחשיפת מדיום להדפסה

A. Tally Eitan-Zeev Pearl & Co.
Law Offices
P-IO-844-IL

FIELD OF THE INVENTION

The present invention relates to an imaging apparatus for a printing system which comprises a plurality of Infra Red (IR) laser diodes and a telecentric lens assembly.

BACKGROUND OF THE INVENTION

Arrays comprising a plurality of laser diodes are well known in the art. In one applications of laser diode arrays, individual diodes can be modulated so as to expose an IR sensitive printing member on a drum. In one known application, the drum is part of a thermal printer as described for example in U.S. Patents Nos. 5,109,460 and 5,168,288 assigned to Eastman Kodak Company (Kodak) of Rochester, New York, U.S.A. In a second application, the drum may be a part of digital printing press as described for example in U.S. Patents Nos. 5,357,617 and 5,385,092 assigned to Presstek Inc. of New Hampshire, U.S.A. In a third application the drum may be a drum of a computer to plate image setter.

Generally speaking, two types of IR diode lasers imaging apparatus are known in the art. In one type, described in the above mentioned patents assigned to Presstek Inc., the light emitted by each laser diode is focused by a corresponding focussing lens. Thus, a large number of lenses are required, whereby the complexity and the cost of the imaging apparatus increase.

In the second type of imaging apparatus, described in the above mentioned patents assigned to Kodak and schematically illustrated in Fig. 1 to which

reference is now made, the thermal printer 1 includes a movable imaging apparatus 10 moving in the direction indicated by arrows 2 to affect line by line scanning on a drum 11 rotating about a longitudinal axis as indicated by arrow 4.

The movable imaging apparatus 10 comprises an array of IR laser diodes 12 of which five, referenced 12A - 12E, are shown in Fig 1. Each laser diode 12 is attached to a corresponding optical fiber 13A - 13E in a pigtail type attachment, the light emitting ends of the plurality of fiber optics are aligned at 14.

In this type, the light from all IR laser diodes 12 is focused onto the drum 11 by a single optical assembly 15. The optical assembly 15 comprises a stationary lens assembly 16 and a movable focusing lens or lens assembly 17. In Fig. 1 an exemplary light path 18C is shown for the light emitted by laser diode 12C to affect exposure of the medium mounted on drum 11 at exposure spot 19C.

One drawback of IR laser diodes is that in order to obtain the output power required to expose the IR sensitive medium, fiber optics with a large diameter, typically 100 microns, and a large numerical aperture, typically larger than 0.2, are required. Moreover, in order to meet quality requirements of the exposed image the focusing lens images the output of the fiber optics with a demagnification ratio of 3, thus leading to a numerical aperture of 0.6 towards the image plane.

Since the numerical aperture of the focusing lens is high, an autofocusing mechanism is designed to compensate for changes in the distance between the surface of the printing member and the aligned light emitting end 14 of the fiber optics 13. This autofocusing compensation mechanism includes the movable lens or lens assembly 17 which is movable between stationary lens assembly 16 and the drum 11 as indicated by arrow 6.

In the illustrated example, lens 17 moves from its position 17 to its position 17' as indicated by arrow 6 so as to change the optical path from 18 to 18' in order to expose the light sensitive medium in exposure spot 19C' thus compensating for the movement of the medium on the drum 11 as indicated by location 11' of the drum.

A drawback autofocusing optical assemblies, in particular ones which provide an accuracy of the exposed spot in terms of location and spot size on the order of microns is their cost and complexity and the fact that they are prone to mechanical failures.

A lens assembly known in the art which replaces autofocus lens assemblies is shown in Fig. 2 to which reference is now made. Fig. 2 illustrates a system similar to that of Fig. 1 except that it includes a stationary lens assembly 25 instead of the autofocus lens assembly 15.

In a system with a prior art stationary lens assembly, a change in the distance between the distance of the printing member on drum 11, schematically illustrated by the dashed drum 11', and the aligned edge 14, results in a change in the location of the corresponding exposure spots from 19A and 19E to 19A' and 19E', respectively. As illustrated in exaggeration for illustration purposes in Fig. 2, the lateral distance between exposure spots 19A' and 19E' is larger than the lateral distance between exposure spots 19A and 19E, i.e., the position accuracy of the exposure spot on the drum 24 is adversely affected by changes in distance between the printing member and the aligned edge of the optical fibers 14.

SUMMARY OF THE INVENTION

It is an object of the present invention to provide an improved imaging apparatus for a printing system.

There is thus provided, according to a preferred embodiment of the present invention, an imaging apparatus which includes a plurality of IR laser diodes each coupled to a corresponding optical fiber, the optical fibers are aligned at a distance from an exposure surface and providing an output light beam, and a stationary telecentric lens assembly which operates to image the output light beam onto the exposure surface.

According to a preferred embodiment of the present invention, the output numerical aperture of the optical assembly is smaller than 0.45 wherein the output numerical aperture of the optical fibers is smaller than 0.15 and wherein the lens assembly having a demagnification power of at least three. Further, the intensity of the laser diodes is at least 0.5 Watt.

Additionally, according to a preferred embodiment of the present invention, the imaging apparatus may also included means for changing the intensity of each the laser diodes. Preferably, the means for changing the intensity of each the laser diodes include means for changing the current of each laser diode during exposure.

According to a preferred embodiment of the present invention, changes in the distance between the exposure surface and the aligned optical fibers are compensated within a range of 60 microns employing the telecentric lens assembly, changes in the distance between the exposure surface and the aligned optical fibers are compensated within a range of 40 microns employing the means for changing the

laser diodes intensity, whereby a total range of compensation of 100 microns is achieved.

There is also provided, in accordance with a preferred embodiment of the present invention, a method for controlling the spot size of an imaging apparatus which includes a plurality of IR laser diodes each coupled to a corresponding optical fiber, the optical fibers are aligned at a distance from an exposure surface and providing an output light beam, and a stationary telecentric lens assembly which operates to image the output light beam onto the exposure surface, the method includes the step of selectively varying during exposure the intensity of the laser diodes so as to reduce or increase the spot size resulting thereby.

Preferably, the step of selectively varying during exposure includes the step of selectively varying the current provided to the laser diodes.

In accordance with a preferred embodiment of the present invention, the step of selectively varying the current includes the steps of pre-exposure calibration of the laser diodes power and on the flight determination of the actual current to be provided to each the laser diode during exposure.

Further, the step of pre-exposure calibration preferably includes the steps of mapping the variations in location of the drum surface with respect to the aligned optical fibers and defining a correction function between the variations in location and the laser diodes intensity.

Still further, the step of on the flight determination includes providing a location on the drum surface, and employing the correction function to determine a correction factor so as to correct the intensity of the laser diode.

According to an alternative embodiment of the present invention, the step of pre-exposure calibration includes the steps of mapping the variations in dot percentage of a reference exposure on the drum surface and defining a correction function between the variations in location and the laser diodes intensity and the step of on the flight determination includes the steps of providing a location on the drum surface and its current dot percentage and employing the correction function to determine a correction factor so as to correct the intensity of the laser diode.

Finally, there is provided in accordance with a preferred embodiment of the present invention a system for exposing a printing member with a pattern representing an image to be printed which includes:

A. a drum for mounting an IR sensitive printing member on a surface thereof, the drum being rotating about a longitudinal axis thereof to affect interline exposure of the printing member with the information representing the image;

B. an imaging apparatus which includes a plurality of modulateable IR laser diodes, each coupled to a corresponding optical fiber, the optical fibers are aligned at a distance from the printing member and providing an output light beam and a stationary telecentric lens assembly which operates to image the output light beam onto the printing member so as to record the information representing the image thereon; and

C. means for moving the imaging apparatus generally parallel to the longitudinal axis of the drum so as to affect intraline exposure of the printing member.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will be understood and appreciated more fully from the following detailed description taken in conjunction with the appended drawings in which:

Fig. 1 is a schematic pictorial illustration of a printing system having a prior art imaging apparatus based on an autofocus lens assembly;

Fig. 2 is a schematic pictorial illustration of a printing system, having a prior art imaging apparatus based on a stationary lens assembly;

Fig. 3 is a schematic pictorial illustration of a printing system, constructed with an imaging apparatus according to a preferred embodiment of the present invention;

Fig. 4 is a schematic block diagram illustration of a preferred method for controlling the spot size of the exposure spots of the imaging apparatus of Fig. 3; and

Fig. 5 is a schematic block diagram illustration of another preferred method for controlling the spot size of the exposure spots of the imaging apparatus of Fig. 3.

DETAILED DESCRIPTION OF THE PRESENT INVENTION

Reference is now made to Fig. 3. Fig. 3 illustrates a printing system 20 which comprises, similarly to the prior art printing system 1, an imaging apparatus 22 and a drum 24. The drum 24 rotates to provide the intraline exposure of a printing member mounted thereon as indicated by arrow 26 wherein the imaging apparatus 22 is movable along a guiding support 27 as indicated by arrow 28 to affect scanning in a line by line fashion of the printing member mounted on drum 24.

The printing system 20 may be any system operative to expose a printing member with a pattern representing an image to be printed. It may be without limitation a digital offset printing press, a thermal printer or a plate setter.

The imaging apparatus 22 comprises, similarly to the prior art imaging apparatus 10, an array of IR laser diodes 32 of which five, referenced 32A - 32E, are shown in Fig 2. Each laser diode 32 is attached to a corresponding optical fiber 33A - 33E in a pigtail type attachment, the light emitting ends of the plurality of fiber optics are aligned at 34. Preferably, the optical fibers 33 are aligned in 34 in a linear array with predetermined spacings therebetween.

The light from all IR laser diodes 32 which is modulated in accordance to the information representing the image to be printed exposed on the printing member mounted on drum 24 is focused onto the drum 24 by a single telecentric lens assembly 35. The telecentric lens assembly 35 is a stationary lens assembly which obviates the use of the autofocus lens mechanism and is advantageous with respect to the stationary lens assembly of the prior art.

It will be appreciated that a particular feature of the present invention is the use of a telecentric optical assembly which is enabled by the use of optical fibers 33 with a relatively small numerical aperture, preferably smaller than 0.15.

It will further be appreciated that an advantage of telecentric optical assemblies is that they provide an effective focusing region, rather than a focal point, with a typical focal depth of tens of microns, whereby a region wherein changes in the distance between the exposure spots on the printing member and the aligned optical fibers 34 are compensated both in terms of position and spot size.

As illustrated in Fig. 3, the drum 24 is shown in two different locations denoted 24 and 24' to indicate a different distance of the printing member mounted thereon and the aligned optical fibers at 34. Within that range, as illustrated in Fig. 3, the use of a telecentric optical assembly 35 results in an equal lateral distance between exposure spots 39A and 39E and exposure spots 39A' and 39E', whereby the accuracy in the position of the exposed spots on drum 24 is retained albeit the change in distance between the printing member and aligned optical fibers 34.

Furthermore, in the embodiment of Fig. 3, the optical fibers 33 are optical fibers having a numerical aperture which is smaller than 0.15, the lens assembly 35 having a demagnification power of up to three so as to provide an output numerical aperture of the imaging apparatus 22 which is smaller than 0.45.

Consequently, within the focusing range the spot sizes of exposed spots 39A and 39A' is similar as is the spot size of exposed spots 39E and 39E'.

An example of an optical fiber having an output numerical aperture smaller than 0.15 usable in the imaging apparatus 22 is SDL-2360-N2, commercially available from SDL Inc. of San Jose, California, USA.

A particular feature of the present invention is that although the numerical aperture of the optical fibers 33 is relatively small, the power of the laser diodes 32 is selected to be relatively high, say 0.5 Watts or more.

According to a preferred embodiment of the present invention, the laser diodes are employed to control the size of the exposed spot on the printing member by varying the intensity thereof as described in detail with respect to Figs. 4 and 5 to which reference is now made.

The method of Fig. 4 comprises pre-exposure calibration steps and on the flight beam intensity determination steps. Information obtained in the pre-exposure calibration steps is integrated with information accumulated during exposure, i.e., on the flight, to provide the desired correction in the intensity of each laser diode so as to compensate for inaccuracies in the spot size of the exposure spot on the printing member mounted on drum 24.

The pre-exposure calibration steps include the step 102 of "mapping" the surface of drum 24. Since the drum 24 and guiding support 27 are not perfect in shape, the distance between the drum surface and the aligned optical fibers 34 is not constant. Therefore, the distance for each location on drum 24, designated XY location and the aligned fibers 34 is measured and data which indicates for each XY location that distance, i.e., whether it is in focus or out of focus with respect to lens assembly 35 is stored.

The pre-exposure calibration steps further include the step 104 of preparing and storing a correction function in which the power of the laser diode for a given out of focus distance for given printing parameters, such as a constant exposed dot percentage, is determined.

Further, the pre-exposure calibration steps also include the step 106 of determining a nominal power of each laser diode 32.

The determination steps are done for each laser diode or for one or more selected calibration diodes. During exposure, on the flight, the beam position for a desired laser diode in X and Y is determined as indicated by steps 108 and 110. For the determined XY position, the out of focus information is provided by retrieving it from the stored results of step 102, to provide the extent of out of focus for that location as indicated by 112.

Then, with the information of the correction function provided from the information determined at 104, a power correction factor 114 is determined. This factor is multiplied by the nominal laser diode current from step 106 to obtain real laser diode driver current 116 which is provided to the diode as indicated in step 118 so as to obtain the correct power which provides the required intensity for compensating for spot size inaccuracy for the selected diode in the selected location. For example, such correction may be made for laser diode 32A for correcting the resulting spot size at 39A and/or 39A'.

It will be appreciated that usually, the above described method will be employed to calibrate a single diode or a limited number of diodes operating as calibration diodes. Variations in the intensity of all other diodes will be done accordingly.

Reference is now made to Fig. 5 which illustrates another method for correcting the beam intensity of the laser diodes so as to correct the spot size of the exposed spots on the drum 24.

The method of Fig. 5, similarly to the method of Fig. 4 includes a number of pre-exposure calibration steps and a number of on the flight correction steps.

In step 202, a pre-exposure pattern is imaged on the drum and a map of the dot percentage resulting therefrom is prepared, i.e. the dot percentage vs. the location XY on drum 24. Step 202 is similar to step 102 except that it is based not on the physical variations in the drum surface but on the variation in dot percentage from a constant dot percentage of a test pattern.

In step 204, a power correction function is computed from the laser power and the deviation of dot percentage from a constant exposed dot percentage. The information obtained in steps 202 and 204 is used as input as well as the nominal laser diode current (step 206) for each laser diode in the on the flight steps.

During exposure, for a beam position XY at 208 and 210, the dot percentage at the XY location is determined as indicated by step 212. Then, in step 214, a laser diode correction factor is computed for a diode, which may be a calibration diode. The laser diode correction factor is then computed from the correction function computed before actual exposure and the current dot percentage for the current XY location.

From the power correction factor (step 214) and the nominal laser diode current 206, a laser diode driver current 216 is computed from which the corrected current 218 to the selected laser diode is drawn.

It will be appreciated that the preferred embodiments described hereinabove are described by way of example only and that numerous modifications thereto, all of which fall within the scope of the present invention, exist. For example,

the printing system 20 may be a flat bed based printing system and not a drum based system as illustrated and described hereinabove.

It will be appreciated by persons skilled in the art that the present invention is not limited to what has been particularly shown and described hereinabove. Rather, the scope of the present invention is defined only by the claims that follow:

CLAIMS

1. An imaging apparatus comprising:

a plurality of IR laser diodes each coupled to a corresponding optical fiber, the optical fibers are aligned at a distance from an exposure surface and providing an output light beam;

a stationary telecentric lens assembly which operates to image said output light beam onto said exposure surface.

2. The imaging apparatus of claim 1 wherein the output numerical aperture of said optical assembly is smaller than 0.45.

3. The imaging apparatus of claim 2 wherein the output numerical aperture of said optical fibers is smaller than 0.15.

4. The imaging apparatus of any of claims 2 - 3 wherein changes in the distance between said exposure surface and said aligned optical fibers are compensated within a range of 60 microns.

5. The imaging apparatus of claim 4 wherein the intensity of said laser diodes is at least 0.5 Watt.

6. The imaging apparatus of any of the previous claims and also comprising means for changing the intensity of each said laser diodes.

7. The imaging apparatus of claim 6 wherein said means for changing the intensity of each said laser diodes include means for changing the current of each laser diode during exposure.

8. The imaging apparatus of claim 7 wherein changes in the distance between said exposure surface and said aligned optical fibers are compensated within a range of 40 microns, whereby a total range of compensation of 100 microns is achieved.

9. A method for controlling the spot size of an imaging apparatus comprising a plurality of IR laser diodes each coupled to a corresponding optical fiber, the optical fibers are aligned at a distance from an exposure surface and providing an output light beam, and a stationary telecentric lens assembly which operates to image said output light beam onto said exposure surface, the method comprising the steps of:

selectively varying during exposure the intensity of said laser diodes so as to reduce or increase the spot size resulting thereby.

10. The method of claim 9 wherein said selectively varying during exposure comprising selectively varying the current provided to said laser diodes.

11. The method of claim 10 wherein said selectively varying the current comprising pre-exposure calibration of said laser diodes power and on the

flight determination of the actual current to be provided to each said laser diode during exposure.

12. The method of claim 11 wherein said pre-exposure calibration comprising:

mapping the variations in location of the drum surface with respect to said aligned optical fibers; and

defining a correction function between said variations in location and said laser diodes intensity.

13. The method of claim 12 wherein said on the flight determination comprises:

providing a location on said drum surface; and

employing said correction function to determine a correction factor so as to correct the intensity of said laser diode.

14. The method of claim 11 wherein said pre-exposure calibration comprising:

mapping the variations in dot percentage of a reference exposure on said drum surface; and

defining a correction function between said variations in location and said laser diodes intensity.

15. The method of claim 14 wherein said on the flight determination comprises:

providing a location on said drum surface and its current dot percentage; and

employing said correction function to determine a correction factor so as to correct the intensity of said laser diode.

16. A system for exposing a printing member with a pattern representing an image to be printed comprising:

a drum for mounting an IR sensitive printing member on a surface thereof, said drum being rotating about a longitudinal axis thereof to affect interline exposure of said printing member with the information representing said image;

an imaging apparatus comprising a plurality of modulateable IR laser diodes, each coupled to a corresponding optical fiber, the optical fibers are aligned at a distance from said printing member and providing an output light beam and a stationary telecentric lens assembly which operates to image said output light beam onto said printing member so as to record the information representing said image thereon; and

means for moving said imaging apparatus generally parallel to the longitudinal axis of said drum so as to affect intraline exposure of said printing member.

17. The imaging apparatus according to any of claims 1 - 8, substantially as described hereinabove.

18. The imaging apparatus according to any of claims 1 - 8, substantially as illustrated in any of the drawings.

19. The method of claims 9 - 15, substantially as illustrated in any of the drawings.

20. The method according to any of claims 9 - 15, substantially as described hereinabove.

21. The system of claim 16, substantially as illustrated in any of the drawings.

22. The system of claim 16, substantially as described hereinabove.

For the Applicant,

A. Tally Eitan-Zeev Pearl & Co.

P-IO-844-IL

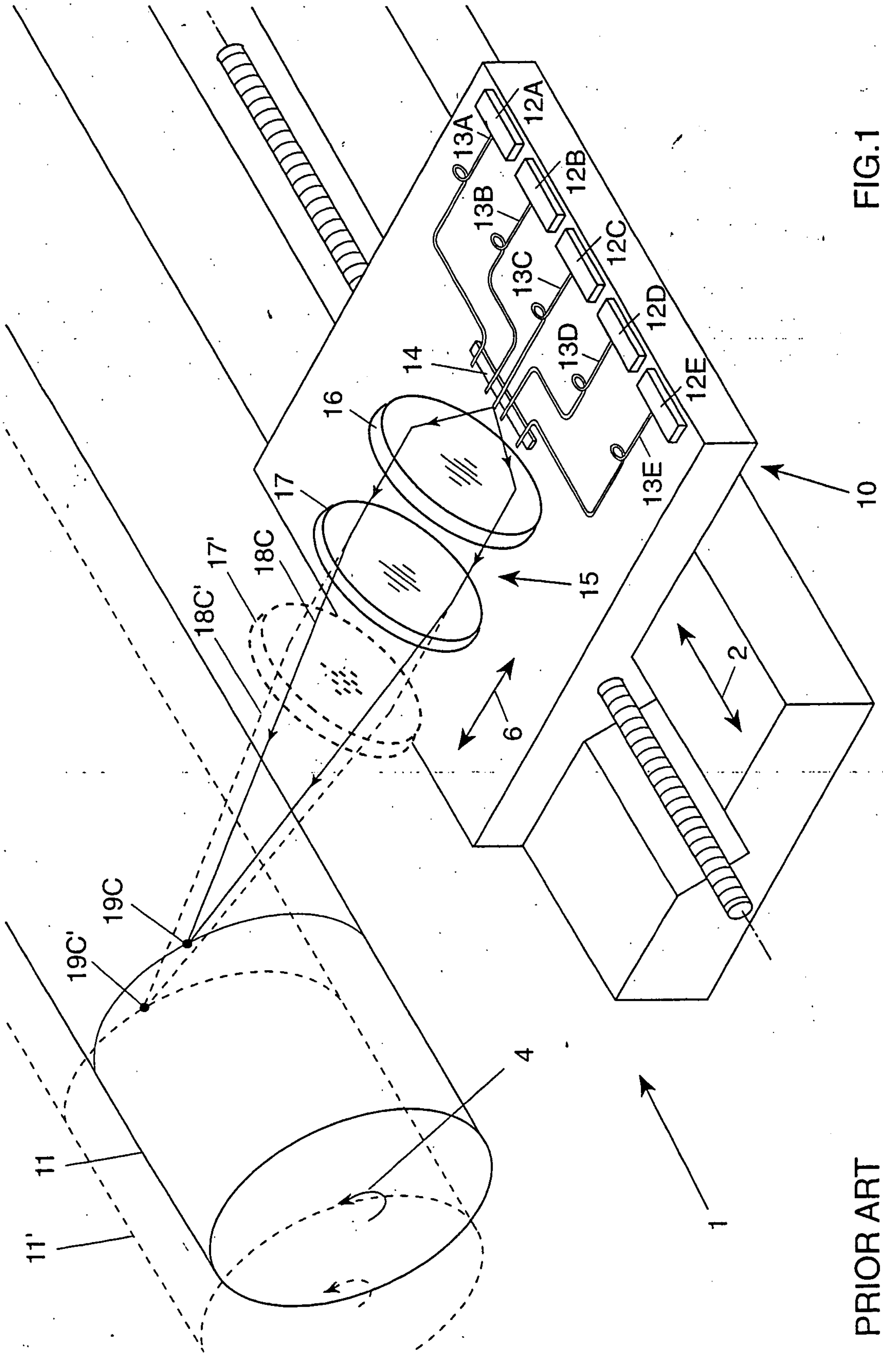

FIG.1

PRIOR ART

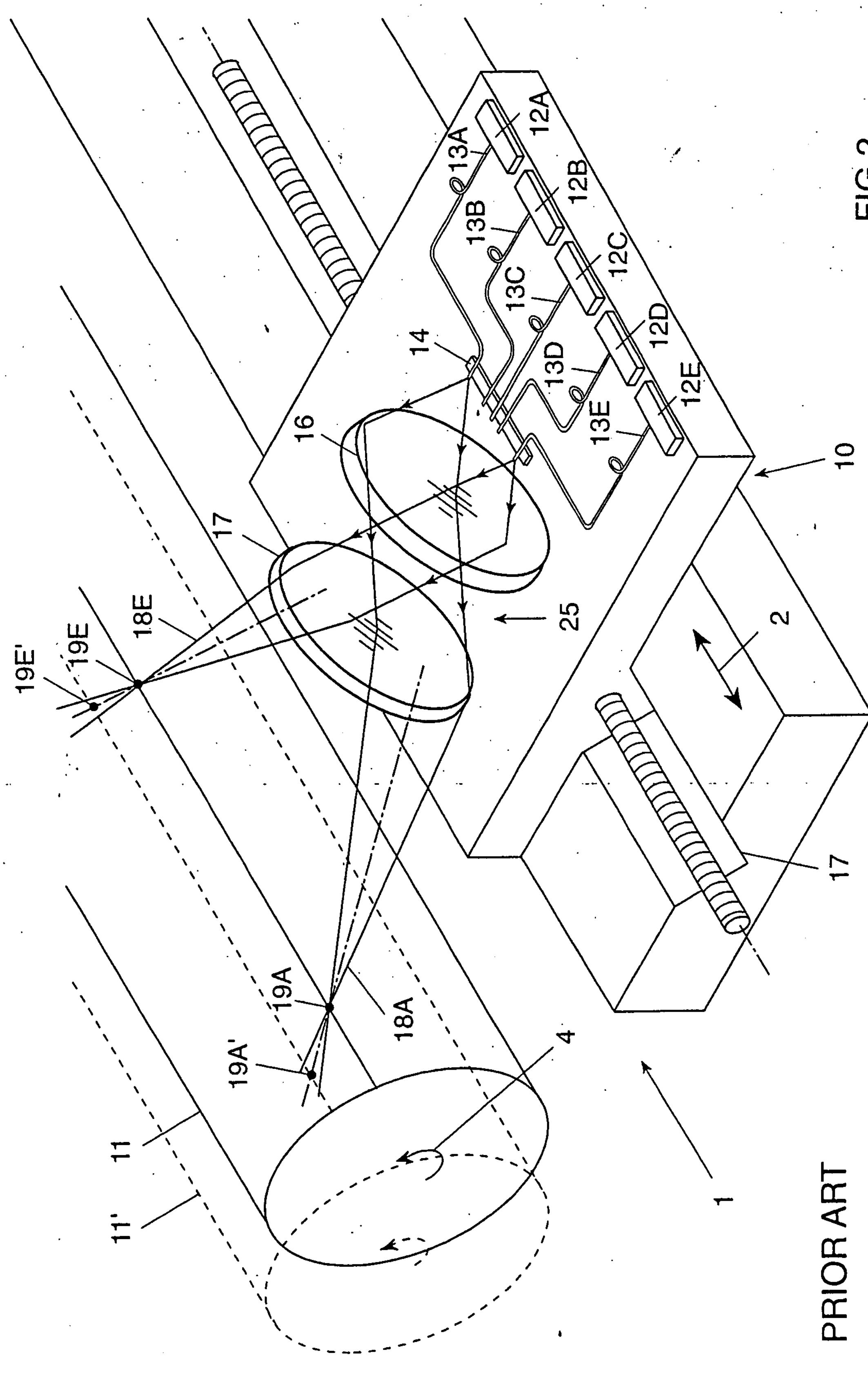

FIG.2

PRIOR ART

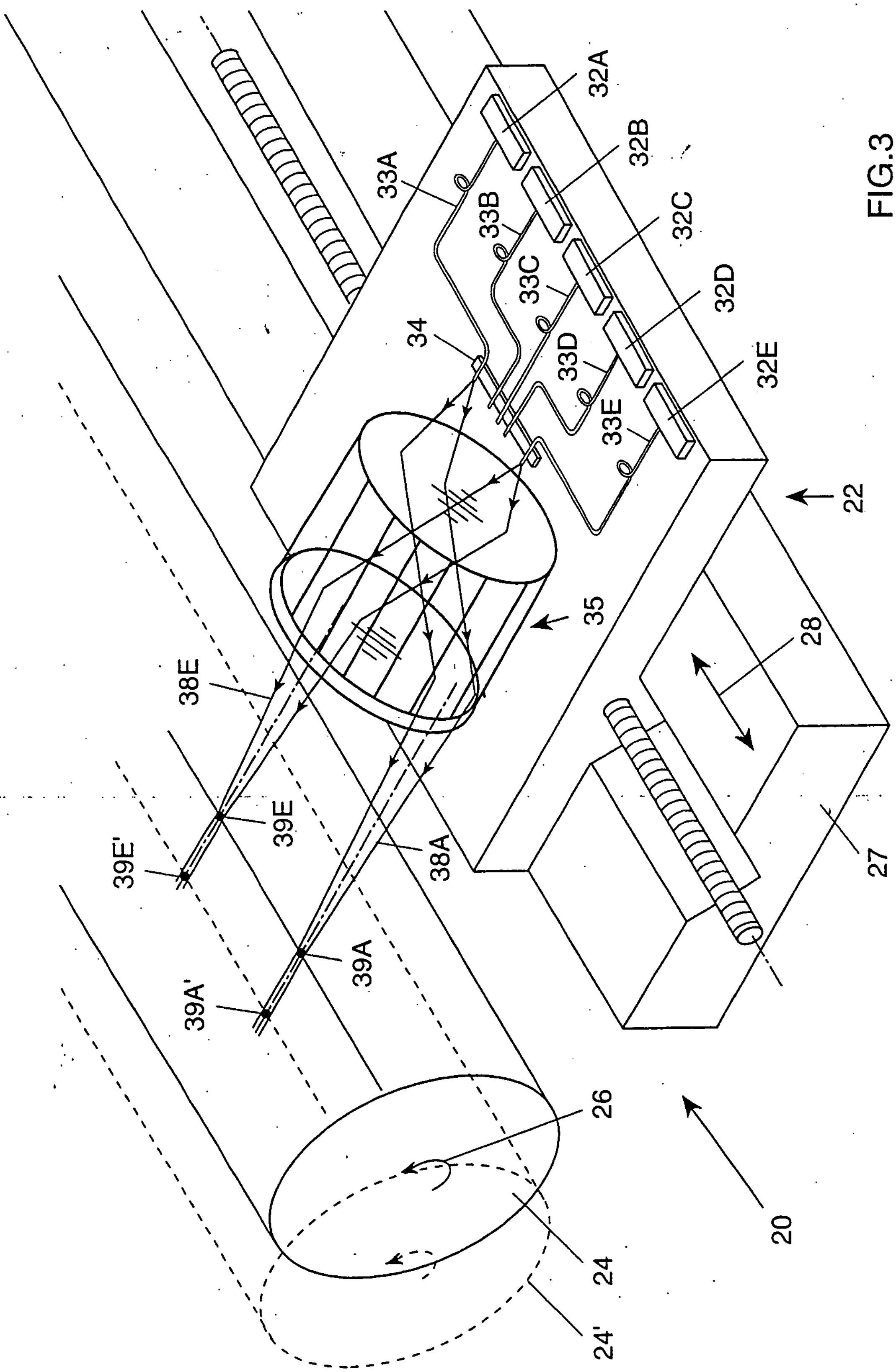
32A
32B
32C
32D
32E
33A
33B
33C
33D
33E
34
35
22
28
27
38E
38A
39E
39E'
39A
39A'
26
24
24'
20

FIG.3

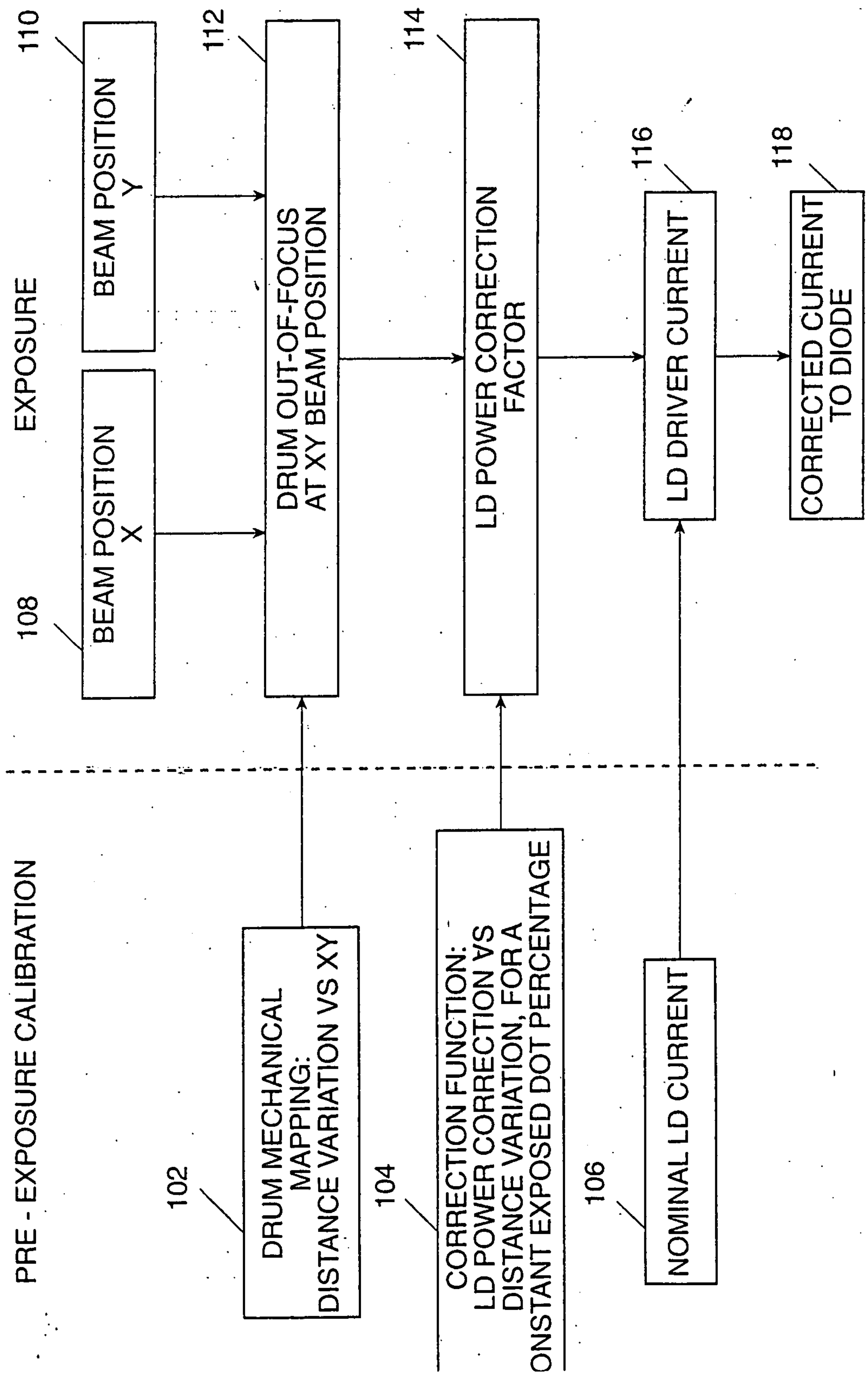
PRE - EXPOSURE CALIBRATION
EXPOSURE
102
DRUM MECHANICAL MAPPING: DISTANCE VARIATION VS XY
104
CORRECTION FUNCTION: LD POWER CORRECTION VS DISTANCE VARIATION, FOR A ONSTANT EXPOSED DOT PERCENTAGE
106
NOMINAL LD CURRENT
108
BEAM POSITION X
110
BEAM POSITION Y
112
DRUM OUT-OF-FOCUS AT XY BEAM POSITION
114
LD POWER CORRECTION FACTOR
116
LD DRIVER CURRENT
118
CORRECTED CURRENT TO DIODE

FIG. 4

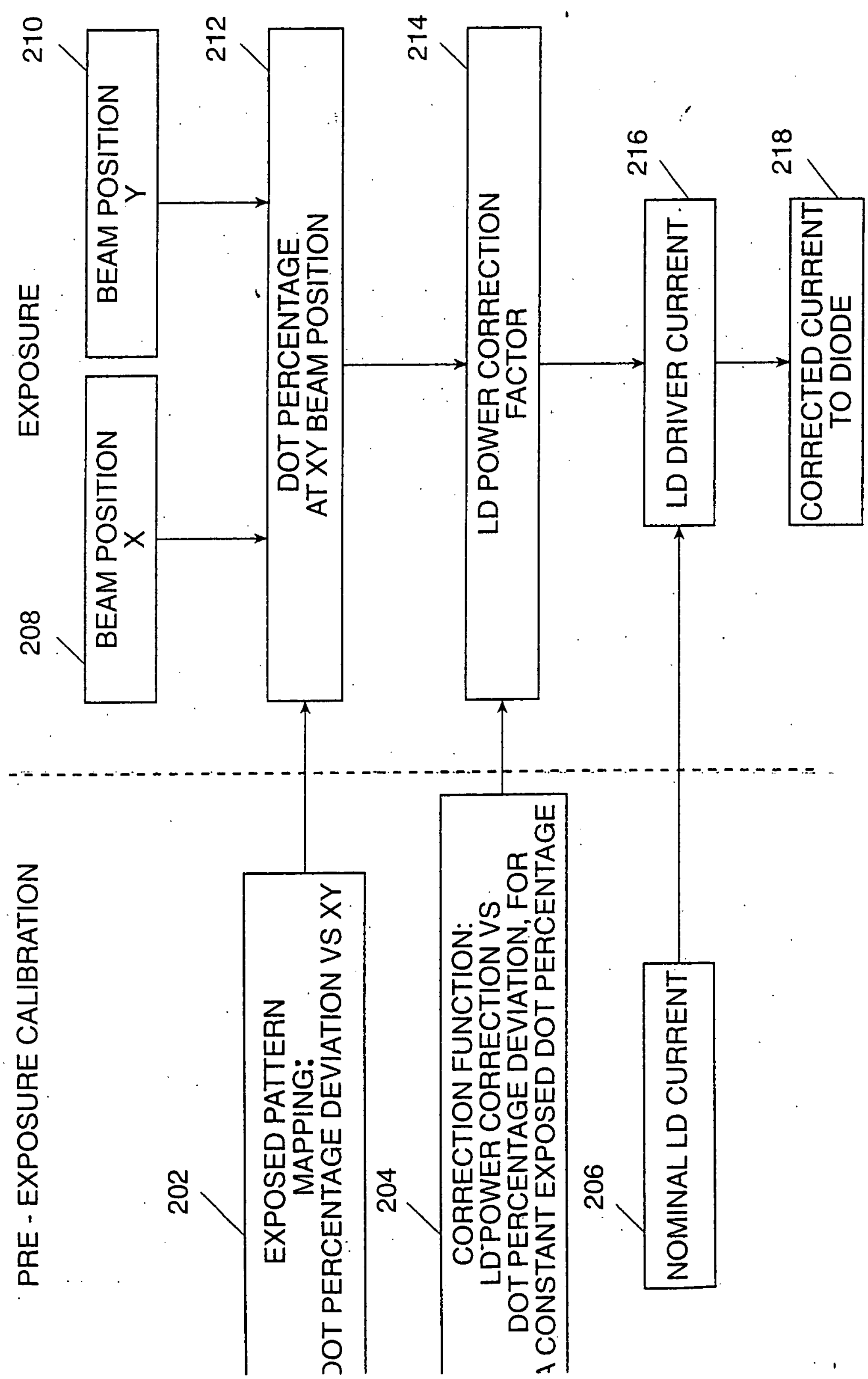
PRE - EXPOSURE CALIBRATION
EXPOSURE
202
EXPOSED PATTERN MAPPING: DOT PERCENTAGE DEVIATION VS XY
204
CORRECTION FUNCTION: LD POWER CORRECTION VS DOT PERCENTAGE DEVIATION, FOR A CONSTANT EXPOSED DOT PERCENTAGE
206
NOMINAL LD CURRENT
208
BEAM POSITION X
210
BEAM POSITION Y
212
DOT PERCENTAGE AT XY BEAM POSITION
214
LD POWER CORRECTION FACTOR
216
LD DRIVER CURRENT
218
CORRECTED CURRENT TO DIODE

FIG. 5